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**Anas Siddiqui**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

**Arun Alfred David**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

**Tarence Thomas**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

**Abdul Anis**
Senior Scientist, C S Azad University, Kanpur, Uttar Pradesh, India

**Shahzad Khan**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

**Ram Bharose**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

**Corresponding Author:**
**Anas Siddiqui**
Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj, Allahabad, Uttar Pradesh, India

# Influence of different level of sulphur and zinc on physico-chemical properties of soil yield attributes and nutrient content of maize (*Zea mays* L.) Shakti 8484

**Anas Siddiqui, Arun Alfred David, Tarence Thomas, Abdul Anis, Shahzad Khan and Ram Bharose**

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## Abstract
An experiment was conducted on "Influence of different level of Sulphur and Zinc on Physico-chemical Properties of Soil yield attributes and Nutrient content of Maize var. Shakti-8484 was executed at the department of Soil Science and Agricultural Chemistry NAI, SHUATS (Allahabad) Prayagraj. The trial was conducted in RBD designed having three level of sulphur and zinc respectively, it was found that the effect of Sulphur and Zinc on soil physical parameters *viz.*, pore space (%) ranged from 54.30% to 67.77%, water retaining capacity ranged from 45.36 to 63.22 and organic carbon (%) ranged from 0.46 to 0.69 and on soil chemical parameters *viz.*, Av. Nitrogen (Kg $ha^{-1}$) ranged from 242.86 to 267.83, Av. Phosphorus (Kg $ha^{-1}$) ranged from 22.14 to 34.73, Av. Potassium (Kg $ha^{-1}$) ranged from 165.71 to 220.31, Av. Sulphur (mg kg-1) ranged from 9.25 to 18.07 and Av. Zinc (mg $kg^{-1}$) ranged from 0.50 to 1.59 were significant and effectively came out in Treatment 9.This effect enhances the formation of protein and ranks along with nitrogen and phosphorus. However, S and Zn nutrient uptake by plants increases with the application of sulphur up to 40 kg $ha^{-1}$ and Zn up to 10 kg $ha^{-1}$ depending on the sulphur and zinc status having protein percentage in maize ranged from 9.40% to 11.75%. A panoramic view of sulphur and Zinc nutrition in maize has been reviewed in this chapter.

**Keywords:** Soil parameters, maize, nutrients, sulphur and zinc

## Introduction
Soil is a mixture of organic matter, minerals, gases, water and living organisms that together support life (Brady and Weil, 2016) [6]. Soil fertility management via organic and inorganic fertilizers can improve fertility and increase maize yield (Gebrehiwot *et al.*, 2016) [13]. Climate, organisms, parent material, relief, and time are some of the factors that affect the formation of soil. Soil is the result of the biochemical weathering of the parent material (Kherawat *et al.*, 2013) [15]. Monitoring soil moisture levels is essential, with optimal levels between 50% and 75% of field capacity, managed through irrigation and water conservation (Kumar *et al.*, 2018) [16]. The main functions of soil are water storage, supply of nutrients for plants, purification, and modification of environmental conditions (Baveye *et al.*, 2016) [4]. The investigated research report says that, chemical soil analyses which was carried out on pH, electrical conductivity, organic carbon content, available sulphur, available zinc given non-significant result, whereas available nitrogen, available phosphorus, available potassium are given significant results in all the treatment combinations like NPKS, farm yard manure and zinc Mishra *et al.*, (2019) [18]. The word "mahiz" in the Taino language of the Caribbean islands appears to be the source of the word "maize," which became "maiz" in Spanish (Oxford dictionary 2015) [20]. Zea mays ssp. mays, the corn plant, is native to Mexico and Central America. It is a member of the Poaceae family and tribe Maydae. Its genome is 2.3 gigabases in size, it has 20 somatic chromosomes, and it has over 32,000 genes (Schnable *et al.*, 2009) [26]. The versatility of maize allows it to thrive in a wide range of agroecologies and sets it apart from other crops. Because it can be used for both human and animal nutrition and as a vital component of many different industrial products, it has become a crop of worldwide importance.

In addition, maize is used globally as a model organism in scientific research. The largest annual production of major staple grains worldwide is 1016.73 million metric tons of maize (FAOSTAT 2013) [11]. In India maize is grown in Karnataka, Madhya Pradesh, Maharashtra, Telangana, Rajasthan Tamil Nadu, Bihar, Uttar Pradesh and Gujrat. Among the maize producing country across the globe, India ranks in $7^{th}$ position. Globally India ranks $4^{th}$ position in terms in total maize growing area. Maize can be grown successfully in variety of soils ranging from loamy sand to clay loam. However, soil with good organic matter content having high water holding capacity with neutral pH are considered good for higher productivity https://farmer.gov.in. In U.P. maize across different cropping system kharif, Rabi and Zaid is estimated at 2.12 million tonnes across 830,000 hectares https://www.business-standard.com/industry/news/uttar-pradesh-govt-aims-to-increase-maize-production-to-over-3-2-mt-124032900360_1.html. India produces 2% of the world's total maize production, 35.91 million tonnes in 2022-23. Generally More over wheat, Maize is set to be the new enviable crop in UP this winter. The State government has decided to ramp up the acreage and production of maize by 53.54%, in upcoming Rabi season. This means that the area under maize cultivation will go up from existing 8.91 lakh hac. to nearly 13.68 lakh ha. While its production will go up from 19.52 lakh metric tonnes (MT) in 2022-23 to over 24.01 lakh MT in the forthcoming season. According to the Ministry of Agriculture and Welfare, Kharif Maize production is estimated at 224.82 Lakh Metric Tonnes in 2023. As compared to previous year an increase of 11 Lakh Metric tonnes reported. According to the reports of Krishi Vigyan Kendra of (Allahabad) Prayagraj, In kharif 2023, Maize was cultivated under 116 ha. area in district and having Production of 1720 Metric tonnes and Productivity of 14.45 (q $ha^{-1}$) reported. Maize needs sufficient soil moisture for growth and yield, and in Prayagraj, irrigation is often necessary due to low rainfall and high temperatures. Proper soil moisture management via irrigation can enhance maize yield (Singh *et al.*, 2017) [27]. Sulphur is an essential nutrient for all organisms due to its function in a large variety of processes. (Tirupathi *et al.*, 2016) [28] applied of sulphur at 60 kg $ha^{-1}$ significantly increased the growth parameters such as leaf area index (3.0), plant height (180 cm), and dry matter (234.7 g $plant^{-1}$ ) and increasing levels up to 80 kg $ha^{-1}$ remained statistically on par (Padma *et al.*, 2018) [21] found a significant increase in growth parameters *viz.* plant height, leaf area index and dry matter production with application of 60 kg sulphur $ha^{-1}$ over control and remained on par with 40 kg $ha^{-1}$ of sulphur application in maize. sulphur at 50 kg $ha^{-1}$ significantly increased the number of grains $row^{-1}$, thousand grain weight and 42% higher yield in maize compared to control (Sanchez *et al*., 2019) [25], sulphur at increasing levels up to 45 kg $ha^{-1}$ gave higher net return and benefit cost ratio in quality protein maize (Jeet *et al.*, 2012) [14]. The Maximum values for plant height at maturity (225 cm), cob diameter (4.29 cm), number of grains per cob (415), biological yield (20.15 tons $ha^{-1}$), grain yield (7.42 tons $ha^{-1}$) and seed protein content (8.96%) were recorded where 15 kg $ha^{-1}$ ZnSO4 + 15 kg $ha^{-1}$ MnSO4 was applied. The use of high analysis fertilizers and a lack of organic mineral supplements are the main causes of soil deficiencies in zinc, an important micronutrient. India's soil zinc deficit has risen from 44% to 48%, with an additional 63% increase predicted by 2025. Stalin and Preetha (2014) [22]. Because maize is a zinc-responsive crop, it helps to improve yield, which raises the maximum net returns to farmers significantly. Zinc is primarily responsible for producing the growth hormone indole acetic acid, which raises the auxin level and boosts maize growth and output. Fajudar *et al.*, (2014) [12]. Zinc insufficiency is a significant risk factor for human health and mortality worldwide. Micronutrient deficiencies have a significant impact on plant growth, metabolism, and reproduction in animals and humans (Rattan *et al.*, 2009) [23]. The kernel of maize is a nutrient-rich and edible component of the plant. It also contains vitamin C, vitamin E, vitamin K, vitamin $B_1$ (thiamine), vitamin $B_2$ (niacin), vitamin $B_3$ (riboflavin), vitamin $B_5$ (pantothenic acid), vitamin $B_6$ (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine. As the typical human diet is low in potassium, potassium is a main nutrient that is present and has good relevance (Kumar and Jhariya, 2013) [17]. Maize germ contains about 45–50% of oil that is used in cooking, salads and is obtained from wet milling process (Orthoefer, Eastman, and List, 2003) [19]. The oil contains 14% saturated fatty acids, 30% monounsaturated fatty acids, and 56% polyunsaturated fatty acids. The refined maize oil contains linoleic acid 54–60%, oleic acid 25–31%, palmitic acid 11–13%, stearic acid 2–3% and linolenic acid 1% (CRA, 2006) [8]. The two main forms of vitamin E present in our diet are alpha (α) and gamma (γ) tocopherols. Maize oil is amongst the rich sources of these tocopherols, especially γ-tocopherol and their reported concentration was 21.3 and 94.1 mg 100 $g^{-1}$, respectively (Sen, Khanna, and Roy, 2006) [9]. Maize silk contains various constituents essential for our diet such as maizenic acid, fixed oils, resin, sugar, mucilage, salt, and fibres (Kumar and Jhariya, 2013) [17].

## Materials and Methods

Keeping in mind the end goal to assess the impact of various sources and techniques for sulphur and zinc application on development, yield and its components synthesis of maize var. Shakti-8484. The proposed research study was conducted during the cropping season of 2023-24 on a sandy loam soil at the experimental site, department of SSAC, NAI, SHUATS (Allahabad), Prayagraj. The field conditions which is located at $25^0$24'30" N latitude, $81^0$ 51'10" E longitude and 98 m above the mean sea level and is situated 6 km away on the right bank of yamuna river, representing the agro-ecological sub region [North alluvium plain zone (0-10% slope)] and agro-climatic zone (Upper Gangetic Plain Region) for physico-chemical examination, soil tests were taken before sowing and after harvesting of maize.

Soil physical parameters are bulk density (Mg $m^{-3}$), particle density (Mg $m^{-3}$), pore space (%) and water retaining capacity (%), Muthuval *et al*. (1992) [29] and chemical properties of soil pH W/V (1:2.5) Jackon (1958) [30], EC (dS $m^{-1}$) (1:2.5) Wilcox (1950) [31], organic Carbon (%) Walkley and Black (1947) [32], nitrogen (kg $ha^{-1}$) Subbiah and Asija (1956) [33], phosphorus (kg $ha^{-1}$) Olsen *et al.* (1954) [34], potassium (kg $ha^{-1}$) Toth and Prince, (1949) [35]. Permissible limit NPK and nano zinc for soil nitrogen kg $ha^{-1}$ low (<280), medium (280-560), high (>560) and phosphorus kg $ha^{-1}$ (<12.25), medium (12.25), high (>25), potassium low (<135), medium (135-335), high (>335). (Awanish *et al*., 2014) [36] and nano zinc (1- 5 ppm) Alloway, *et al.*, (2008) [37]. Soil texture of the soil sample was taken on depth of 0-15cm. Sand 66.64 (%), Silt 24.09 (%) and Clay 16.27 (%) was observed which indicates soil texture sandy loam. Soil colour was observed at different depths, with a light yellowish-brown color in dry conditions and an olive brown colour in wet conditions. Crop calendar provides a general framework for pre-sowing field operations for maize. Adjustments might be necessary based on your specific climate, soil conditions, and other factors. Tillage operation (Open ploughing by mould board plough followed by harrowing and ploughing), Layout and demarcation of plot (Manually), collection of soil sample for analysis (Randomly from a depth of 0-15 cm), fertilizer application Sulphur and Zinc, Seed sowing (Manually) Plant observation is included hight (cm) number of cobs, yield (q $ha^{-1}$).

**Table 1:** Physico-chemical properties of pre-sowing soil of experimental field

| S. No. | Particulars | Results |
|---|---|---|
| **1.** | **Soil Texture** | **Sandy loam** |
| (i) | Sand | 61.25 (%) |
| (ii) | Silt | 22.15 (%) |
| (iii) | Clay | 16.60 (%) |
| **2.** | **Physical Parameters** | |
| (i) | Bulk density (Mg $m^{-3}$) | 1.57 |
| (ii) | Particle Density (Mg $m^{-3}$) | 2.51 |
| (iii) | Water Retention Capacity% | 43.30 |
| (iv) | Pore Space (%) | 54.10 |
| **3.** | **Chemical Parameters** | |
| (i) | pH (1:2.5) | 7.62 |
| (ii) | EC (dS $m^{-1}$) | 0.31 |
| (iii) | Organic carbon (%) | 0.45 |
| (iv) | Av. Nitrogen (kg $ha^{-1}$) | 241.36 |
| (v) | Av. Phosphorus (kg $ha^{-1}$) | 21.61 |
| (vi) | Av. Potassium (kg $ha^{-1}$) | 165.64 |
| (vii) | Av. Sulphur (mg $kg^{-1}$) | 8.52 |
| (viii) | Av. Zinc (mg $kg^{-1}$) | 0.45 |

The test field was furrowed twice, developed, compaction, ridging, leveled and after that detached into the test units (4 $m^2$). The region of each plot was 2m x 2m for each reproduce; planting was done at a dispersing of 20 cm x 70 cm. Maize grains (Zea mays L.) var. Shakti-8484 were hand sown in July 18, 2023 season. Nitrogen, phosphorus and potassium fertilizer were connected at rate of 150, 70, 70 kg nourished, as Urea (46% N), DAP (15.5% $P_2O_5$) and MOP (48% $K_2O$), K and P and half dosage of N were individually full measurements of the connected at sowing before the primary water system for all medications. While Sulphur was given as basal dose along with NPK and Zinc (Zn) as soil and applied in top dressing with two application procedures.

**Table 2:** Treatment Combinations of maize

| Treatment | Treatment Combination |
|---|---|
| $T_1$ | [Sulphur @ 0 kg $ha^{-1}$ + Zinc @ 0 kg $ha^{-1}$] |
| $T_2$ | [Sulphur @ 20 kg $ha^{-1}$ + Zinc @ 0 kg $ha^{-1}$] |
| $T_3$ | [Sulphur @ 40 kg $ha^{-1}$ + Zinc @ 0 kg $ha^{-1}$] |
| $T_4$ | [Sulphur @ 0 kg $ha^{-1}$ + Zinc @ 5 kg $ha^{-1}$] |
| $T_5$ | [Sulphur @ 20 kg $ha^{-1}$ + Zinc @ 5 kg $ha^{-1}$] |
| $T_6$ | [Sulphur @ 40 kg $ha^{-1}$ + Zinc @ 5 kg $ha^{-1}$] |
| $T_7$ | [Sulphur @ 0 kg $ha^{-1}$ + Zinc @10 kg $ha^{-1}$] |
| $T_8$ | [Sulphur @ 20 kg $ha^{-1}$ + Zinc @10 kg $ha^{-1}$] |
| $T_9$ | [Sulphur @ 40 kg $ha^{-1}$ + Zinc @ 10 kg $ha^{-1}$] |

## Results and Discussion

**Table 1:** Effect of different level of sulphur and zinc on pore space and water holding capacity of soil

| Treatments | Pore space (%) | WHC (%) |
|---|---|---|
| | 0-15 cm | 0-15 cm |
| $T_1$ | 54.30 | 45.36 |
| $T_2$ | 57.87 | 46.24 |
| $T_3$ | 59.40 | 52.01 |
| $T_4$ | 56.50 | 53.58 |
| $T_5$ | 59.83 | 55.28 |
| $T_6$ | 61.40 | 58.22 |
| T7 | 63.20 | 60.02 |
| $T_8$ | 66.87 | 62.12 |
| $T_9$ | 67.77 | 63.22 |
| F- test | S | S |
| S. Em. (±) | 0.44 | 0.22 |
| C.D. @ 5% | 0.94 | 0.47 |

As reported in table 1 the maximum pore space of soil at depth 0-15 cm maximum was 67.77 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 66.87 [Sulphur @ 50% + Zinc @ 100%] and minimum 54.30 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] were significant respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10] and the maximum water holding capacity (%) of soil at depth 0-15 cm maximum was 63.22 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 62.12 [Sulphur @ 50% + zinc @100%] and minimum 45.56 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] were significant respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10].

**Table 2:** Effect of different levels of Sulphur and Zinc on organic carbon and organic matter of soil at different depths

| Treatment | Organic carbon (%) | Organic matter (%) |
|---|---|---|
| | 0-15cm | 0-15 cm |
| $T_1$ | 0.46 | 0.791 |
| $T_2$ | 0.48 | 0.825 |
| $T_3$ | 0.54 | 0.928 |
| $T_4$ | 0.57 | 0.980 |
| $T_5$ | 0.62 | 1.066 |
| $T_6$ | 0.63 | 1.083 |
| $T_7$ | 0.66 | 1.135 |
| $T_8$ | 0.68 | 1.169 |
| $T_9$ | 0.69 | 1.186 |
| F- test | S | S |
| S. Em. (±) | 0.01 | 0.01 |
| C.D. @ 5% | 0.02 | 0.01 |

As revealed in table 2 that the maximum organic carbon of soil at depth 0-15 cm maximum was 0.69 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 0.68 [Sulphur @ 50% + Zinc @ 100%] and minimum 0.46 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively. were significant respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10] and the maximum organic matter (%) of soil at depth 0-15 cm maximum was 1.186 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 1.169 [Sulphur @ 50% + Zinc @ 100%] and minimum 0.791 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] were significant respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10].

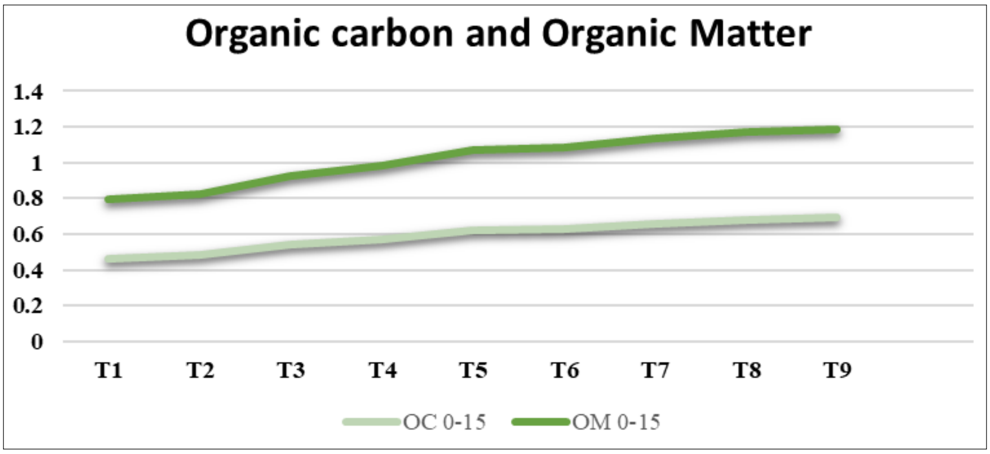


**Fig 2.** Effect of various sulphur and zinc on organic carbon (%) and organic matter (%).

**Table 3:** Effect of different levels of Sulphur and Zinc on nitrogen, phosphorous and potassium (Kg ha$^{-1}$) at 0-15 cm

| Treatment | Nitrogen (Kg ha$^{-1}$) | Phosphorus (Kg ha$^{-1}$) | Potassium (Kg ha$^{-1}$) |
|---|---|---|---|
| | 0-15 cm | 0-15 cm | 0-15cm |
| $T_1$ | 242.86 | 22.14 | 165.71 |
| $T_2$ | 247.68 | 24.63 | 174.60 |
| $T_3$ | 253.75 | 26.46 | 181.02 |
| $T_4$ | 256.18 | 23.71 | 188.03 |
| $T_5$ | 252.87 | 29.48 | 199.30 |
| $T_6$ | 258.64 | 32.49 | 204.62 |
| $T_7$ | 262.48 | 25.56 | 212.71 |
| $T_8$ | 264.71 | 31.60 | 218.02 |
| $T_9$ | 267.83 | 34.73 | 220.31 |
| F- test | S | S | S |
| S. Em. (±) | 0.24 | 0.11 | 0.40 |
| C.D. @ 5% | 0.50 | 0.24 | 0.84 |

As depicted table 3. the maximum nitrogen (Kg ha$^{-1}$) of soil at depth 0-15 cm maximum was 267.83 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 264.71 [Sulphur @ 50% + Zinc @ 100%] and minimum 242.86 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10], and the maximum phosphorus (Kg ha$^{-1}$) of soil at depth 0-15 cm maximum was 34.73 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 31.60 [Sulphur @ 50% + Zinc @ 100%] and minimum 22.14 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10]. As reported in table 4 the maximum potassium (Kg ha$^{-1}$) of soil at depth 0-15 cm maximum was 220.31 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 218.02 [Sulphur @ 50% + Zinc @ 100%] and minimum 165.71 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively were significant respectively These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10].

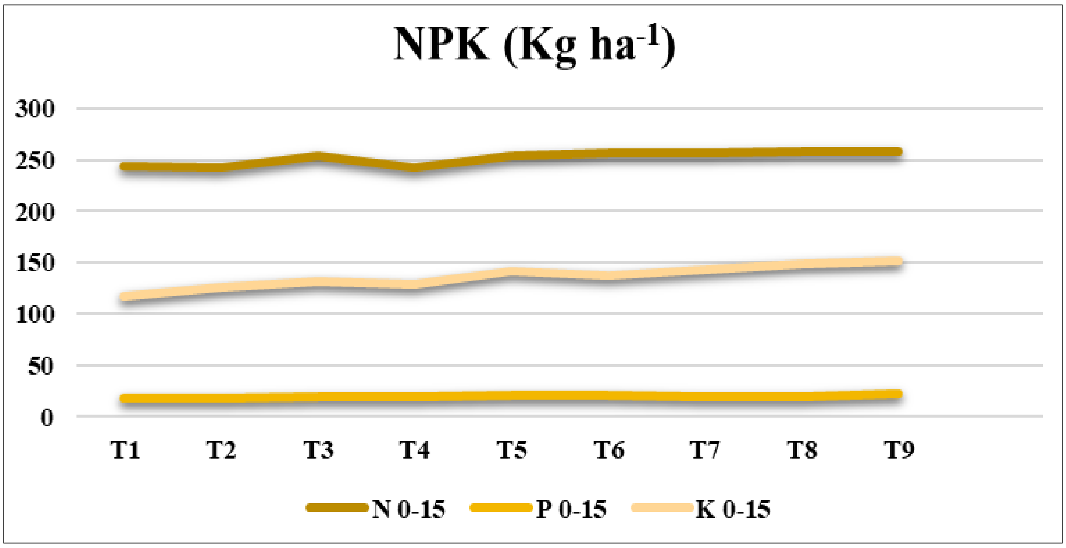


**Fig 3.** Effect of various Sulphur and zinc on nitrogen phosphors and potassium.

**Table 4:** Effect of different levels of Sulphur and Zinc on Av. Sulphur (Mg kg$^{-1}$) and Av. Zinc (Mg kg$^{-1}$) at 0-15 cm

| Treatments | Av. Sulphur (Mg kg$^{-1}$) | Av. Zinc (Mg kg$^{-1}$) |
|---|---|---|
| $T_1$ | 9.25 | 0.50 |
| $T_2$ | 11.76 | 0.78 |
| $T_3$ | 15.17 | 0.94 |
| $T_4$ | 13.25 | 1.02 |
| $T_5$ | 14.87 | 1.19 |
| $T_6$ | 16.05 | 1.24 |
| $T_7$ | 12.64 | 1.37 |
| $T_8$ | 16.42 | 1.46 |
| $T_9$ | 18.07 | 1.59 |
| F-Test | S | S |
| S. Em. (±) | 0.15 | 0.09 |
| C.D. @ 5% | 0.32 | 0.20 |

As depicted table 4. the maximum Sulphur (mg Kg$^{-1}$) of soil at depth 0-15 cm maximum was 18.07 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 16.42 [Sulphur @ 50% + Zinc @ 100%] and minimum 9.25 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively.
These results were in close conformity with the findings of These outcomes closely matched the conclusions reached by Bharath *et al.*, 2017 [5] and the maximum Av. zinc (mg Kg$^{-1}$) of soil at depth 0-15 cm maximum was 1.59 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 1.46 [Sulphur @ 50% + Zinc @ 100%] and minimum 18.22 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] respectively. These outcomes closely matched the conclusions reached by Saad drissi *et al.*, 2017 [24].

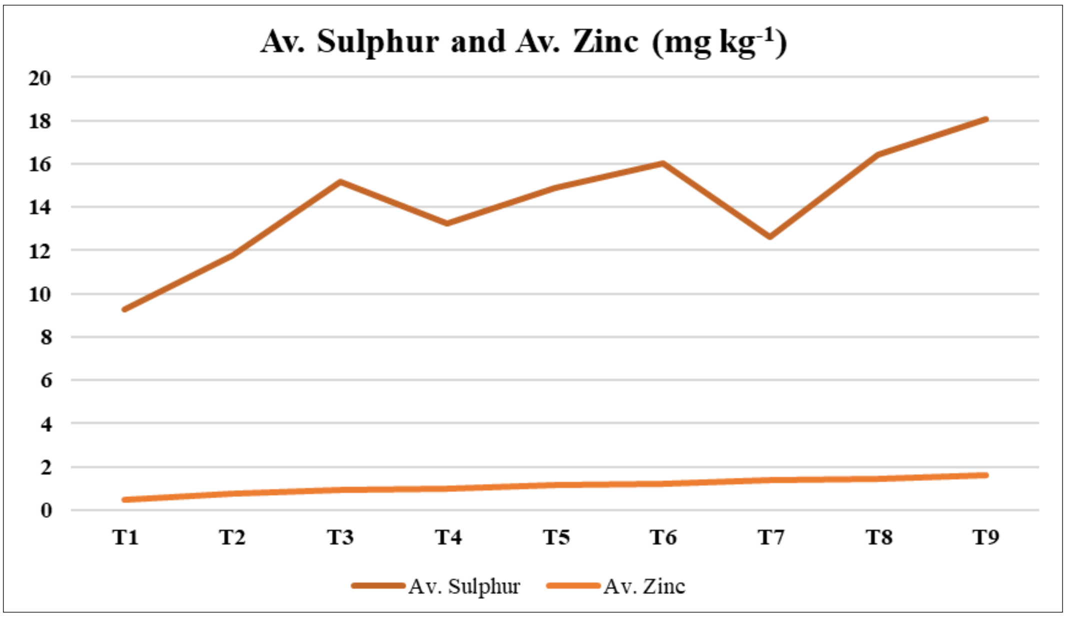


**Fig 4:** Av. Sulphur and Av. Zinc (mg kg$^{-1}$)

**Table 4:** Effect of different levels of Sulphur and Zinc on soil pH (w/v) and EC (dS m$^{-1}$) at 0-15 cm

| Treatment | pH (w/v) | EC (dS m $^{-1}$) |
|---|---|---|
| | 0-15cm | 0-15cm |
| $T_1$ | 7.65 | 0.33 |
| $T_2$ | 7.57 | 0.34 |
| $T_3$ | 7.42 | 0.35 |
| $T_4$ | 7.62 | 0.36 |
| $T_5$ | 7.41 | 0.38 |
| $T_6$ | 7.21 | 0.41 |
| $T_7$ | 7.53 | 0.42 |
| $T_8$ | 7.32 | 0.44 |
| $T_9$ | 7.10 | 0.45 |
| F- test | NS | NS |
| S. Em. (±) | - | - |
| C.D. | - | - |

As described in table 4 the maximum pH of soil at depth 0-15 cm maximum was 7.61 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_6$ 7.53 [N:P: K @ 50% + Nano Zinc @ 100%] and minimum 7.41 was in treatment $T_2$ [Sulphur @ 50% + zinc @100%] were non-significant. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10].
As reported in table 4 the maximum EC (dS m$^{-1}$) of soil at depth 0-15 cm maximum was 0.44 in treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] followed by $T_8$ 0.43 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 0.31 was in treatment $T_1$ [Sulphur @ 0% + Zinc @ 0%] were non-significant. These outcomes closely matched the conclusions reached by Dekhane *et al.* (2011) [10].

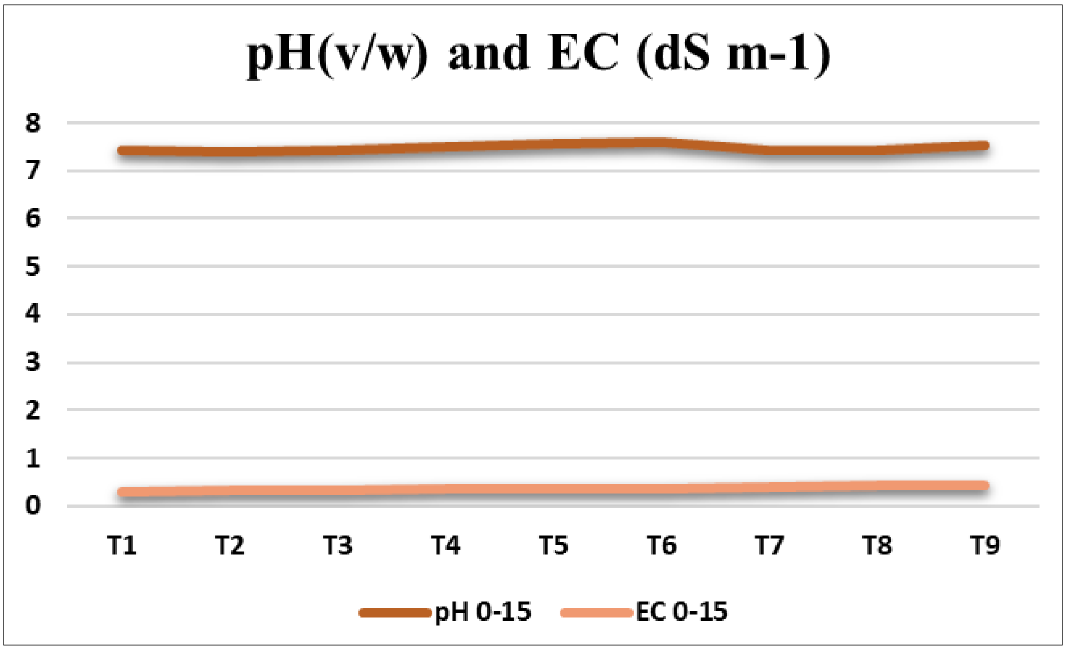


**Fig 4:** Effect of various Sulphur and zinc on pH (v/w) and EC (dSm$^{-1}$).

The protein content was calculated by measuring the nitrogen content of the sample using the Micro Kjeldahl Method. The protein content of the products was calculated by multiplying the nitrogen content of the material by a factor of 6.25 (General factor). Three hundred milligram of moisture-free sample were digested with 3 g of digestion mixture (5:1 $K_2SO_4$+$CuSO_4$) and 10 ml of concentrated $H_2SO_4$ until the contents became clear. The digested sample was then diluted with 50 mL of distilled water before being made alkaline with 40 mL of NaOH (40 percent). The ammonia liberated during distillation was collected in a 250 ml conical flask containing 25ml of 4 percent boric acid and two drops of indicator. Then the solution was titrated against 0.1 N HCl. The nitrogen content is determined using the following Formula:

$$\text{Percentage Nitrogen} = \frac{\text{(ml HCl in determination- ml blank) x Normality of HCl}}{\text{Weight of the sample}} \text{ x } 100$$

Crude protein content (g) = Percent Nitrogen *6.25

**Table 5:** Effect of different levels of Sulphur and Zinc on Protein% of maize

| Treatments | Protein% |
|---|---|
| $T_1$ | 09.40 |
| $T_2$ | 10.25 |
| $T_3$ | 11.10 |
| $T_4$ | 09.85 |
| $T_5$ | 10.45 |
| $T_6$ | 11.50 |
| $T_7$ | 10.10 |
| $T_8$ | 10.80 |
| $T_9$ | 11.75 |
| F-Test | S |
| S. Em. (±) | 0.25 |
| C.D. | 0.53 |

As descripted in table 5, the maximum Protein percentage of maize was maximum in Treatment $T_9$ [Sulphur @ 100% + Zinc @ 100%] which is 11.75 followed by $T_6$ [Sulphur 100% + Zinc @ 50%] which is 11.50 and minimum was in treatment $T_1$ [Sulphur 0% + Zinc @ 0%] which is 9.40.

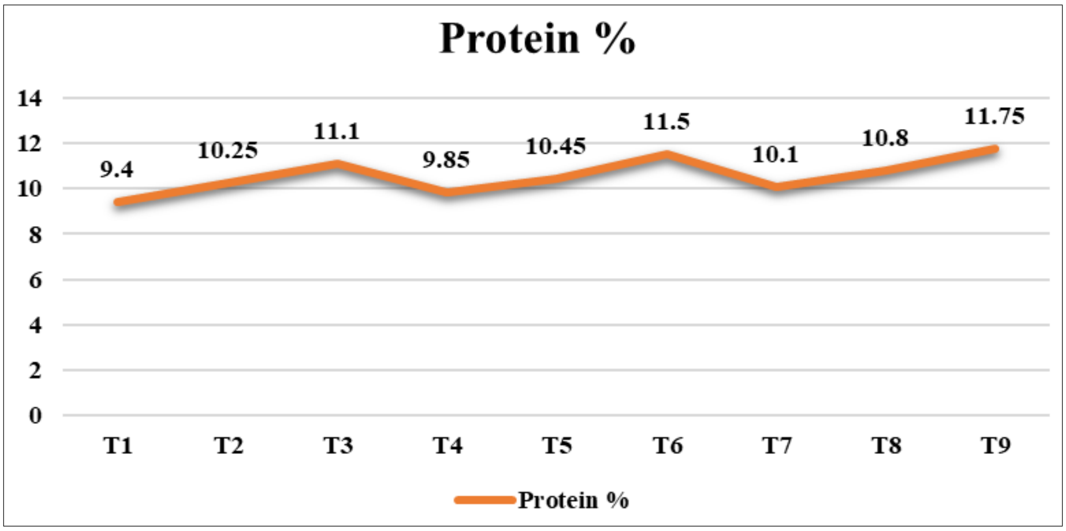


**Fig 4:** Effect of various Sulphur and zinc on Protein content of maize in different treatments.

## Summary
Influence of Different level of sulphur and zinc on Physico-chemical Properties of Soil Yield Attributes and Nutrient Content of Maize (*Zea mays* L.) var. Shakti 8484. in *kharif* season 2023 at Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments and 3 replications. Sulphur (S) is crucial for plant growth, affecting soil pH, nutrient availability, and microbial activity. Similarly, zinc (Zn) plays a vital role in enzyme function, hormone synthesis, and overall plant development. When applied to soil, different levels of S and Zn can alter soil pH, organic matter content, nutrient availability, and microbial diversity. These changes can have both positive and negative effects on soil health and plant growth, depending on factors such as soil type, crop type, and environmental conditions. Therefore, understanding the interactions between sulphur, zinc, and soil physico-chemical properties is essential for optimizing agricultural practices and ensuring sustainable crop production. Addition of sulphur and zinc results in the betterment of the soil Health and also it helps in protein formation. $T_9$ treatment with [40kg $ha^{-1}$ Sulphur and 10kg $ha^{-1}$ Zinc enhances the yield from 25 q $ha^{-1}$ to 46 q $ha^{-1}$]. The maximum bulk density (Mg $m^{-3}$) 1.59 Mg $m^{-3}$, particles density (Mg $m^{-3}$) 2.52 Mg $m^{-3}$ and soil pH 7.65 were recorded in $T_1$. The maximum porosity (%) 68.22%, water holding capacity (%) 62.78, electrical conductivity (dS $m^{-1}$) 0.45 dS $m^{-1}$, organic carbon (%) 0.69, available nitrogen (kg $ha^{-1}$) 267.83kg $ha^{-1}$, available phosphorous (kg $ha^{-1}$) 34.73 kg $ha^{-1}$ and available potassium (kg $ha^{-1}$) 220.31 kg $ha^{-1}$ was recorded in $T_9$.

## Conclusion
It is concluded that the experimental trial which was conducted on maize by using different levels of sulphur and zinc, it was found that the significant with increase in soil fertility and also shown significance on yield parameters with $T_9$ [sulphur @ 40kg $ha^{-1}$ + zinc @ 10 kg $ha^{-1}$], it has shown the highest yield production of 46.97 q $ha^{-1}$ followed by $T_6$ of 42.30 q $ha^{-1}$,The protein percentage is also reported in $T_9$ with 13.49% followed by $T_6$ with 13.12%.

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